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The bascule railway bridge over the South Beveland Canal

on the Roosendaal-Flushing line, near Vlake, Holland,

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The importance of the traffic on the South Beveland Canal has made it necessary to replace the swing bridge near Vlake by a new structure at a higher level.

This new work consists of :

(1) Two new approaches in reinforced concrete, with track laid on ballast and spanning the two highways running alongside the canal at this point;

(2) Two fixed lattice girder metal trough bridges of 69-m. (226 ft. 4 5/8 in.) span, carrying a single track with floor on the bottom booms;

(3) Finally, two single-track bascule bridges, coupled together, over the canal itself, so providing two channels for navigation.

The navigable space under the two fixed lattice bridges is 64 m. (213 ft. 3 1/8 in.) wide, and the free height above water level 7.5 m. (24 ft. 7 1/4 in.) for vessels. (The inspection and maintenance trolleys are housed above the pier in the stream, outside the clearance space for vessels.)

The navigable channel below the bascule bridges is 18 m. (59 ft. 5/8 in.) wide, with a free height above water level of 6.30 m. (20 ft. 8 in.), with bascules down (fig. 1).

Most vessels are able to pass beneath the fixed trellis spans, the bascules only having to be raised for sea going vessels and those with non-collapsible masts.

A common substructure carries the railway bridge and a road bridge situated a little to the south of the former. This road bridge is designed on the same plan as the railway bridge and carries the normal traffic using the new section of the national highway between Roosendaal and Flushing (fig. 2).

The distance between the centres of the two tracks — the minimum allowable depending on the permissible space between the lattice spans for the inspection trolleys to pass — was fixed at 7 m. (22 ft. 11 5/8 in.). In addition,

the control cabin for the bascules is situated between the tracks and, taking into account a 4.40-m. (14 ft. 5 1/4 in.) width necessitated by the loading gauge, there remains a space of 2.60 m. (8 ft. 6 3/8 in.) for the cabin (fig. 3).

The bascule bridges are of the solid web main girder type with top flooring (see fig. 3). The two single-track bascules, which have longitudinal and transverse wind bracing, are over the navigable space, braced together by transverse wind bracing of bracket form, as well as a general one of K form.

This K-form bracing allows of the longest bascule leaf, when open, to keep clear of the control cabin. In this way the bridge keeper always has perfectly clear view of the canal, whether the bridge is open or closed. Incidentally the place selected for the cabin also allows the bridge keeper to watch both railway lines.

The railway bascule bridges rotate round a common fixed shaft D. This passes through the four main girders with a certain amount of play, both vertical and horizontal (fig. 4).

This shaft rests on four supports L provided with bronze bearings and securely bolted to the main substructure. The play between the main girders and the pivot shaft is such (see fig. 4), that the latter is not stressed when the span is closed, neither by the dead weight of the bascule nor by the moving loads.

The device used to allow the shaft to support the weight of the leaves when raised will be described later on.

The bascules, for the purpose of carrying the moving loads, rest solely on the bearings O_L and O_K (see fig. 3), situated at the ends of the two unequal arms, the lengths of which, measured from the shaft, are 21.70 m. (71 ft. 2 3/8 in.) and 9.35 m. (30 ft. 8 1/8 in.) respectively.

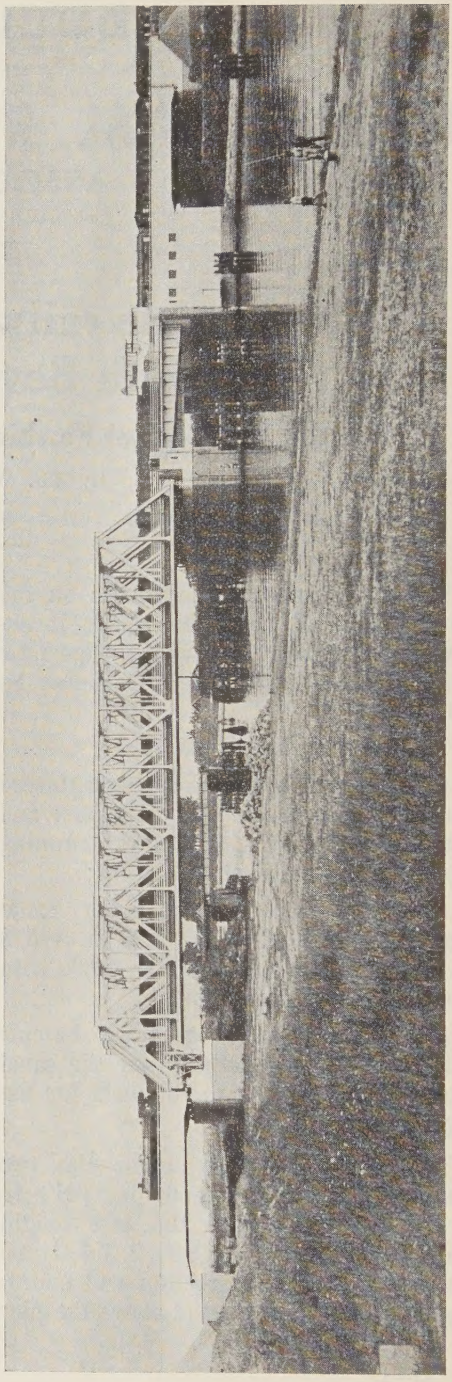


Fig. 1. — General view of the new structure seen from the south, showing in the foreground the road overbridge. In the background is seen the old railway swing bridge, now out of service.

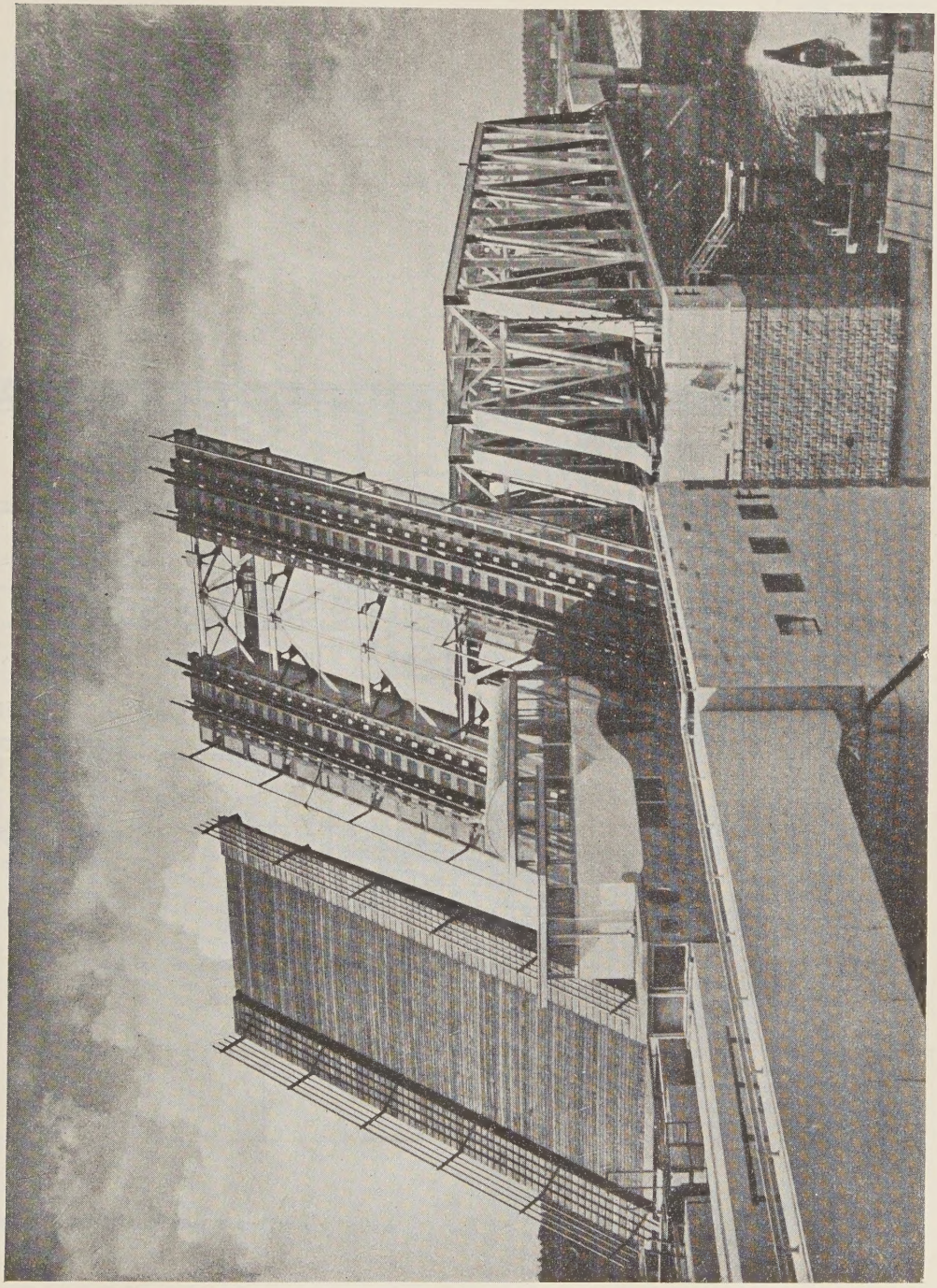


Fig. 2. — The braced spans of the railway bascule bridge partly raised, with the control cabin between them; to the south the road bascule bridge, also partly raised.

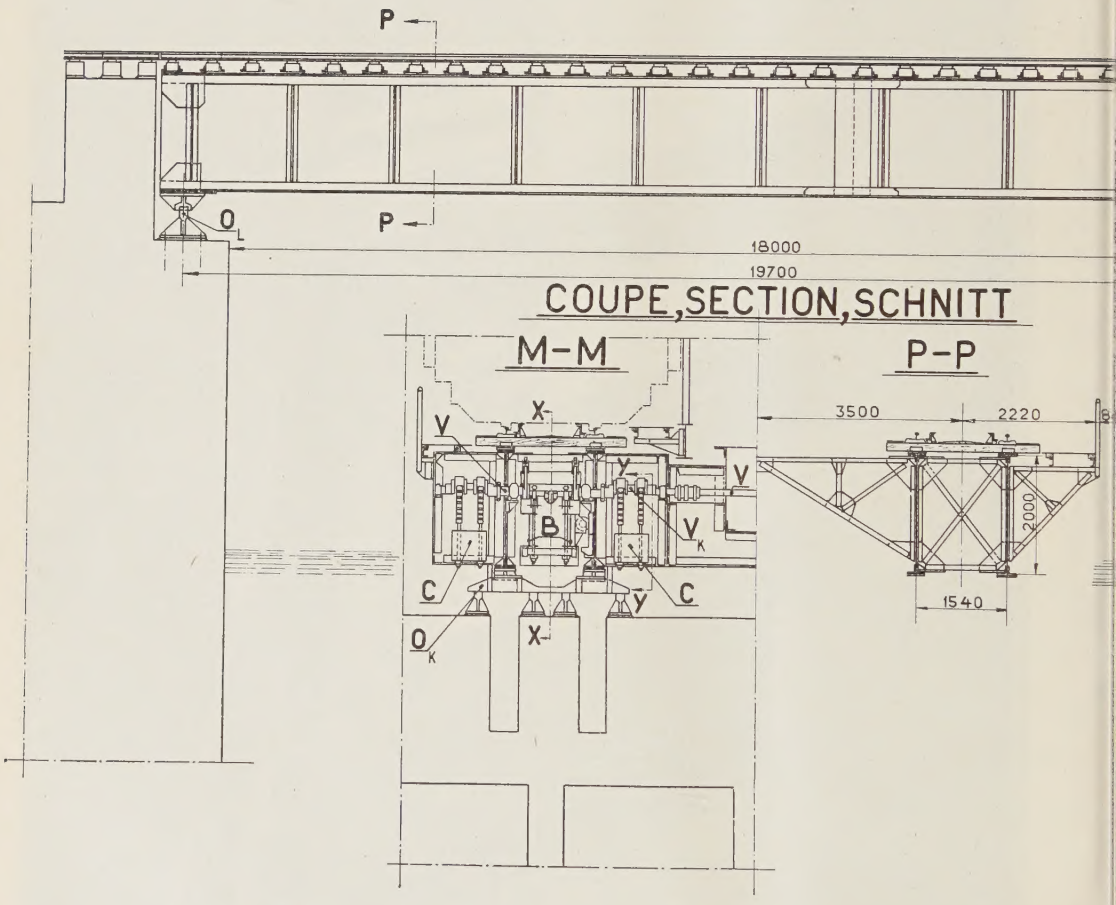
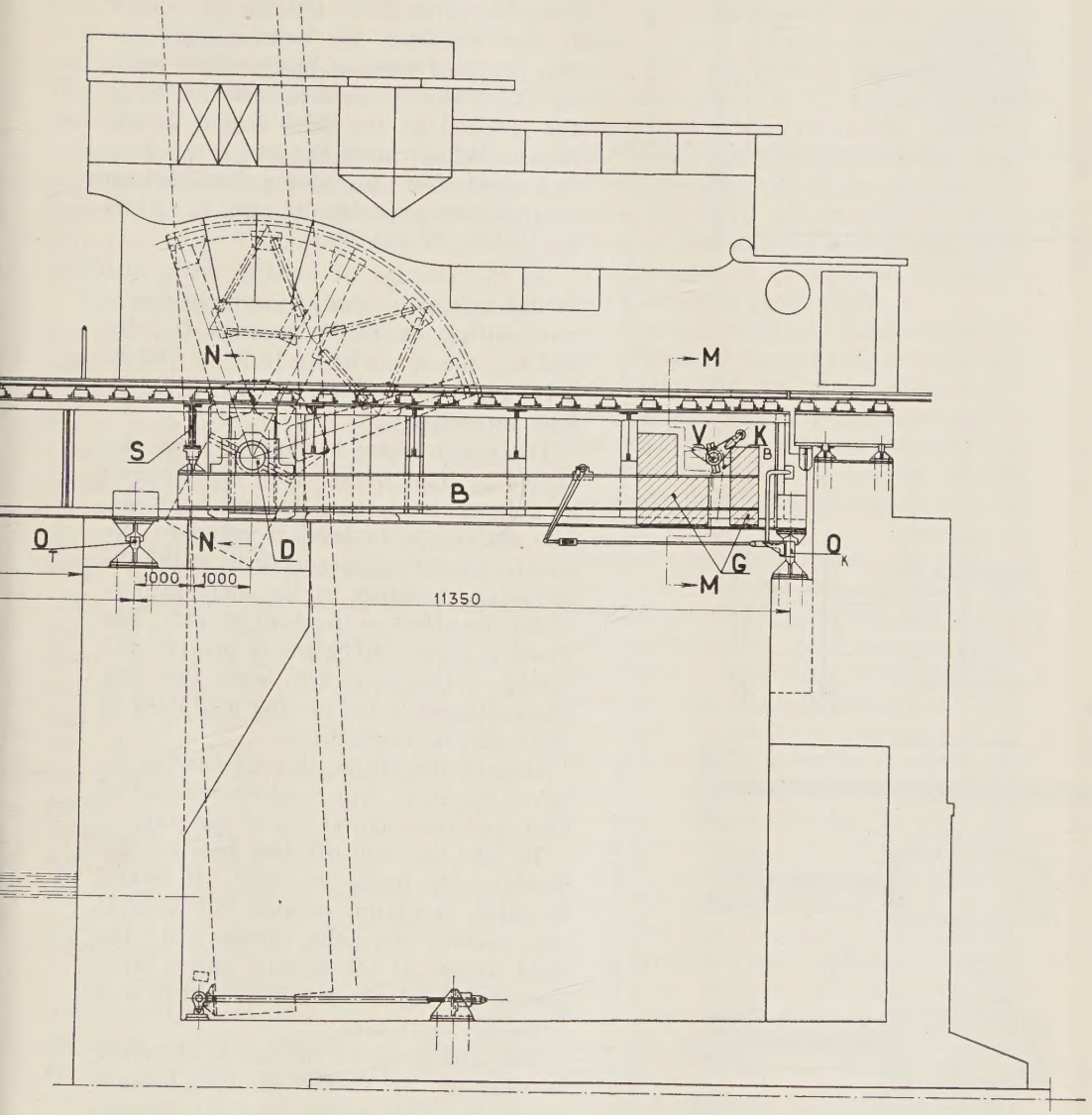


Fig. 3. — Diagrammatic longitudinal cross section



ailway bascule bridge, with two transverse cross sections.

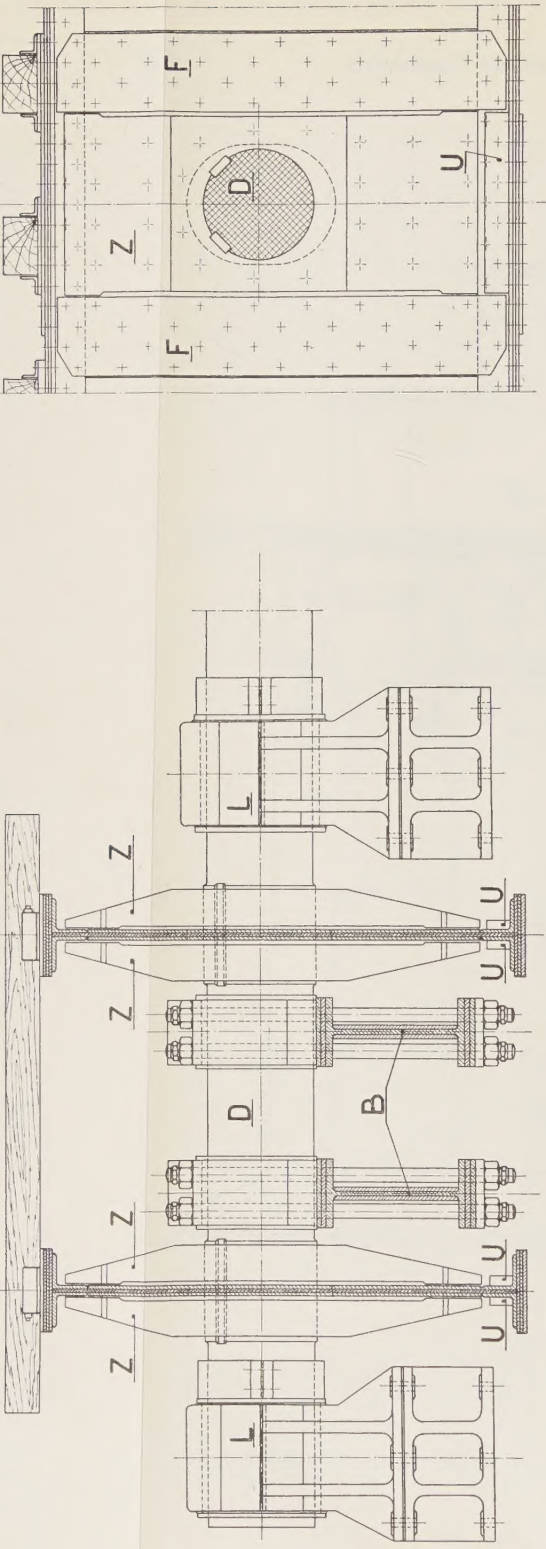


Fig. 4. — Transverse cross section N-N relating to fig. 3, with part view of a main girder. In the web of the latter is seen dotted the oval shaped opening through which the main shaft passes, this itself being shown in section.

At a distance of 2 m. (6 ft. 6 3/4 in.) from the pivot shaft, towards the longer of the two arms, the main girders are also provided with an intermediate bearing O_T. This is so arranged that it is not stressed by the dead weight of the spans. When closed the two arms, long and short, form together a fixed bridge resting on two bearings O_L and O_K, 31.05 m. (101 ft. 11 in.) apart.

On the passage of moving loads, the bridge acts as a continuous fixed structure resting on three bearings O_L, O_T and O_K, the spans being 19.70 m. (64 ft. 8 1/4 in.) and 11.35 m. (37 ft. 2 7/8 in.) long respectively.

The intermediate bearings O_T are designed as fixed ones. They are situated at a lower level than the end bearings. The difference in level is equal to the amount of deflection sustained at the intermediate bearings by the main girders under the effect of the dead weight. The whole is amply sufficient to prevent any lifting of the short arm when the long one is subject to the moving load used as basis for the calculations.

To raise the bridge, the end bearing O_K below the short arm must be relieved of load, and then moved out of the way.

To take the load off this bearing, the whole of the bridge is lifted. It should be noted, as a guide to what follows, that this bearing normally carries half the dead weight of the bascule and a large part of the balance weight placed in line with the short arm.

The lifting up of the whole structure is effected by means of two balance beams B. This action does not necessitate any outside effort save that required to overcome frictional resistance.

Each balance beam is mounted between the main girders of an arm and revolves round the fixed pivot shaft D already mentioned. The long arm of each beam

is suspended near the end of the short bascule arm by means of the chains K_B to a cranked shaft V/V_K [hereinafter called the lifting shaft (opzetas), or releasing shaft] around which the suspension chains are coiled.

Each beam acts through its short arm on the superstructure beneath a cross-tie beam S, at a point on the long bascule arm 1 m. (3 ft. 3 3/8 in.) from the pivot shaft.

The raising and lowering of the bridges is effected by the rotation of the shaft V/V_K.

For raising them, the shaft V/V_K rotates in such a sense that the chains KB unwind, the long arms of the balance beam descending. To lower the bascules, the shaft V/V_K rotates in the opposite direction, winding up the chains, the long arms of the balance beams rising.

To make sure that, after the raising, the ends of the back arms are completely clear of their bearings, the balance weight provided in line with them is given such a value that the centre of gravity of the whole, including all fixed and movable loads, to be discussed later, comes a little in front of the point at which the balance beams act. In this way, after the small lift given just at the beginning, the ends of the long bascule arms still rest on their bearings O_L and exert a light pressure thereon.

The balance beams are provided with counter-weights G (see fig. 3). These are such that the product of the total weight (balance beams and counterweight) and the distance between the centre of rotation and a vertical line through the centre of gravity of the whole is equal to the product of the weight of the bridge (including the fixed and moving load weights) and the length of the short arm of the balance beam.

In other words, as soon as the lifting shaft has rotated sufficiently for the bridge to rest entirely on the balance beams, the suspension chains of the beams are relieved of all tension and the bridge as a whole is on the point of being lifted. At that moment the common centre of gravity of the bascules, including the fixed and movable loads, as well as of the balance beams with their counterweights, is situated on the centre line of the main pivot shaft.

After a predetermined height of lift, at which the outer bearings O_K are removed clear, when the bridge is ready to be operated, the respective positions of the balance beams and bascules are such that the common centre of gravity of the whole coincides with the centre line of the pivot shaft.

During the rotation of the bridge round the horizontal axis, therefore, the whole of the structure is in equilibrium.

The main girders of the bascules when closed have a downward curvature. On the other hand, when the bridge has been raised this curvature is reversed. The balance and cross-tie beams on which the bascules rest, as well as the main shaft, are equally deflected under the load. Before the bascules can be lifted effectively all these curvatures must be counteracted and completely modified.

In order that the elastic deformations can be modified without external effort during the process of lifting, equilibrium must exist at every instant between the balance beams and the whole structure.

Since the degrees of deflection due to elastic forces are directly proportional to the loads tending to produce them, the influence of the balance beams must in this connection increase progressively from zero to the maximum amount required.

This equilibrium is brought about and maintained in the following manner during the modification of the elastic forces.

As has been stated above, when the bascules are closed the balance beams are suspended on the lifting shaft, their long arms being attached thereto by the fully wound up chains.

The Galle chains K_B are coupled through revolving pins to arms attached to the lifting shaft V.

In the closed position of the bascules the shaft V has been turned sufficiently to allow of the short arms of the balance beams being clear of the bearing points of the bascules, which amounts to saying that the long arms of the balance beams are raised sufficiently (fig. 5).

A slight play between the short arms of the balance beams and the points of support of the bascules suffices to prevent these arms from being overloaded when moving loads pass over the bridge, seeing that the deflection of the main girders in line with these points is practically negligible.

The distance between the pivot shaft and the balance beam suspension shaft, the weight and centres of gravity of those beams and their counterweights, are known factors. It is thus easy to determine the force with which the balance beams B act on the above-mentioned suspension chains K_B, the spans being closed.

Given the thickness of the chains, that of the drums around which they are coiled, and the diameter of the pivot shaft, the moment to which that shaft is subjected by the whole suspension mechanism can be calculated.

In order to counteract this moment, the pivot shaft could be subjected to a moment of opposite sign, induced for example, by attaching to the shaft crank arms fitted with counterweights.

At the instant when the elastic stresses in the girders are counteracted and then made effective in a different manner, that is to say at the moment when the balance beams no longer exert any tractive effort on the chains and have to carry the whole weight of the bascules with the fixed and movable load weights, the resisting moment or couple has to be reduced to zero. This can be done by a form of construction in which the line of suspension of the counterweights referred to above crosses the pivot shaft exactly on its centre line.

In this manner, equilibrium between the balance beams and the bascules complete would only be effective at the commencement and at the end of the lifting process and not in the intermediate positions.

The tractive effort in the suspension chains K_B of the balance beams at the first upward movement of the bridge diminishes progressively from its maximum value to zero. The length of leverage exercising this pull does not change with respect to the axis of rotation. Consequently the moment with respect to this axis decreases progressively, from its maximum value to zero, proportionally to the angles of rotation described.

When the lifting shaft is being rotated, the counterweight of the resisting moment does not change. On the other hand, the length of its leverage with respect to the axis of rotation, and hence the moment, decreases proportionally to the cosine of the angle of rotation, *not in direct proportion* to that angle (fig. 6).

In order to decrease the resisting moment from its maximum value to zero in accordance with a lineal law, during the rotation of the shaft V, previous to the

bridge being raised, the counterweight C (the moving weight above mentioned, suspended by means of the crank arms V_K and the lifting shaft V to the short arm of the bascule span) does not act directly on the crank arm V_K, but through a special attachment W, around which the suspension chains K of the movable load weight are coiled.

In order that this reduction shall follow a straight line law from maximum to zero, the curve representing the vertical section of the part W, perpendicular to the lifting shaft, must possess the following property : — the difference in the length between the perpendiculars dropped from the centre of rotation V on the tangents to this curve at any two points is directly proportional to the value of the angle formed by these two perpendiculars. From this it follows that the curve in question must be an involute of a circle.

Let R be the radius at which the suspension chains of the balance beams are coiled round the lifting shaft (see fig. 5), and H the height through which the ends of their long arms must descend to modify the elastic forces.

To effect these modifications in the elastic curves the lifting arm must turn through an angle equal to

$$\frac{H}{2\pi R} \times 360^\circ = \frac{H}{\pi R} \times 180^\circ.$$

During this rotation the leverage of the movable weight must pass from its maximum value to zero.

Let A be the length of leverage necessary (see fig. 6).

It follows from the construction of the involute of the circle that the diameter of the generating circle of the involute must be equal to

$$\frac{\pi R}{H} \times A.$$

After the lifting shaft has rotated sufficiently to modify the elastic force curves, the suspension chains K_C of the movable weight cut the centre line of that shaft and are maintained in that position by a hook (see (fig. 7).

The position of the bridge is then as follows : its framework has a convex form upwards and rests, together with the fixed and movable balance weights, with its entire weight on the short arms of the balance beams (see fig. 8). It is only in contact with the end bearings O_L and O_K, being completely free of the intermediate ones. The suspension chains of the balance beams K_B are free of all tension and there is perfect equilibrium between the bridge framework, including the fixed and movable balance weights, and the balance beams with their counterweights.

To free the supports O_K, situated under the ends of the short bascule arm, in order to remove these supports before the spans are rotated, the metallic framework, with fixed and movable balance weights, has still to be lifted. The effort required to do this is small, for the framework and weights are in perfect equilibrium with the balance beams and their counterweights.

The small effort necessary for this purpose is effected (see fig. 8) by the pressure exerted on the end of the arms T, of balance beams B, equipped with rollers and attached to the releasing shaft V. These rollers come in contact with the balance beams on the subsequent rotation of the lifting shaft in the releasing direction.

This lifting shaft, fixed to and turning in the metal framework of the bridge, lifts, by means of the rollers mentioned above, the end of the short bascule arm with respect to the balance beam.

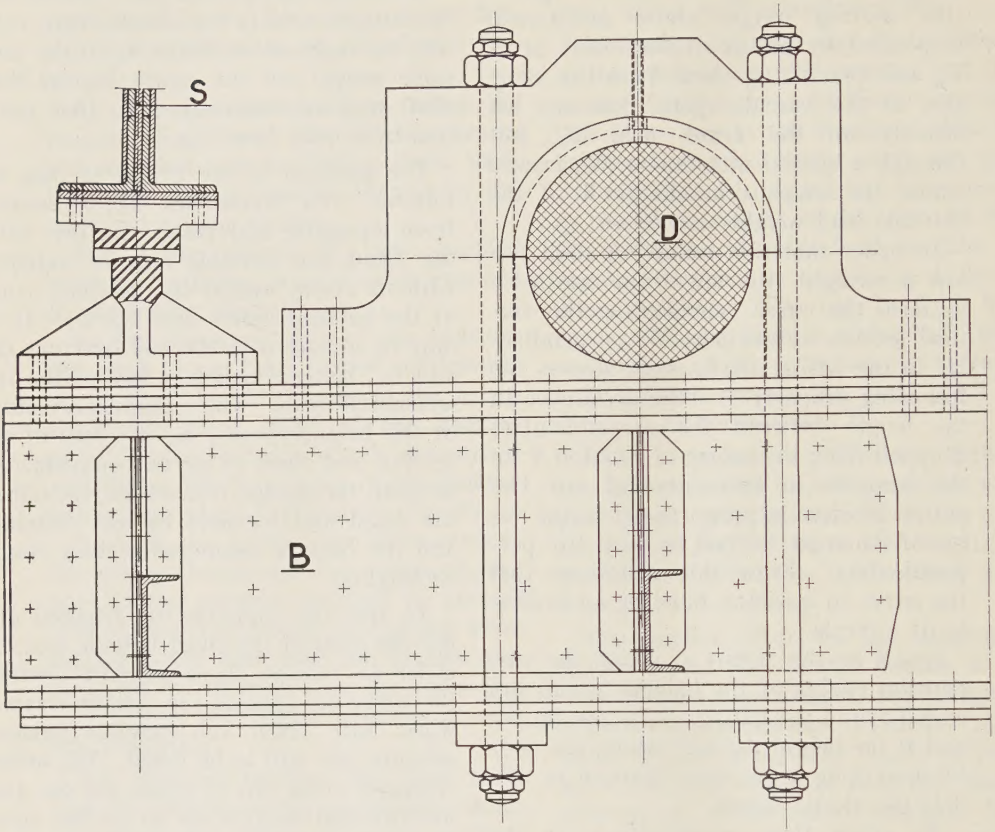


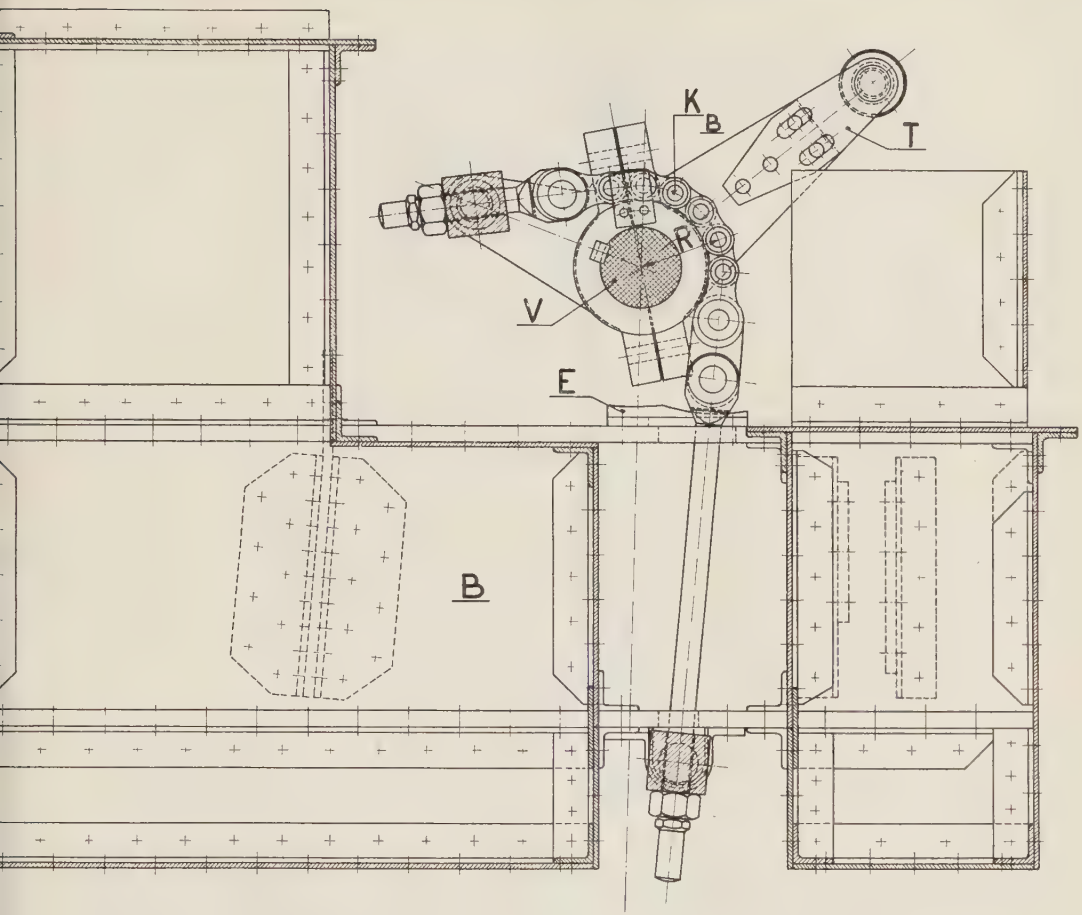
Fig. 5. — Longitudinal cross section X-X through a balance beam as shown

Consequently the end bearings O_K are free and can be withdrawn later whilst, as explained above, the ends of the long bascule arm remain in contact with their bearings O_L and exert a slight pressure thereon.

When the end of the short bascule arm rises with respect to the balance beam, contact is at length effected between the balance beams and the bridge framework.

These contacts occur in such a manner that after the removal of the bearings O_K, suspended from the framework of the bridge, the centre of gravity of that framework with its accessory attachments, and of the balance beams with their counterweights, is situated exactly on the centre line of the lifting shaft, so that, when the bridge is being raised, equilibrium is obtained in every position.

The removal of the bearings O_K is effected through coupling rods attached to the lifting shaft. These bars set in mo-



ransverse cross section M-M in fig. 3, the bascules being in the closed position.

tion a system of levers offering a fixed point of rotation with respect to the framework of the bridge. This is very simply obtained by an additional rotary movement on the part of the releasing shaft after the short bascule arm has been lifted.

The balance beams, after having come in contact with the bridge framework, occupy a fixed position with respect to the latter. On the other hand the releasing shaft still has to be able to accomplish a supplementary rotary movement in order to allow the end bearings to be withdrawn.

The rolling path E (see fig. 8) of the rollers of arms T is formed by the concave portion of a circle whose centre is the axis of the releasing shaft.

From this it results that the relative position of the balance beams and the framework of the bascules remains unaltered during subsequent rotation of the releasing shaft.

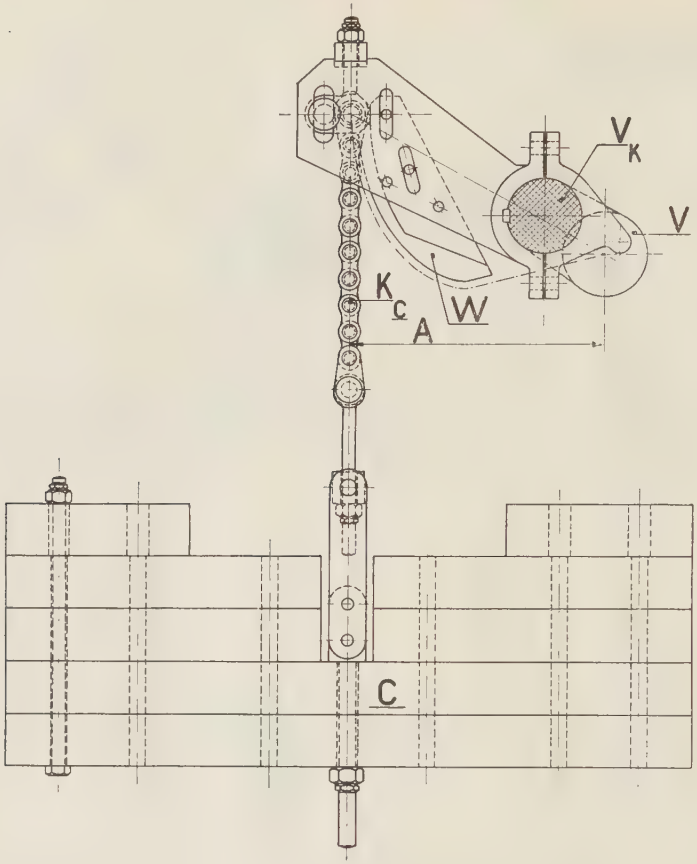


Fig. 6. — Longitudinal cross section Y-Y, as shown in the transverse cross section M-M in fig. 3, with view of movable weight C, in closed position of bascules.

The concave circular curve E likewise permits, after the releasing motor has been switched out, the arms T to be withdrawn during the braking of the lifting gear and so avoid any undesirable strain on that device.

This concave circular release face also serves to prevent the releasing mechanism being subjected to a rotary movement during the rotation of the bascule spans; this point will be referred to again later on.

For the sake of completeness, attention should be directed to the fact that for the spans to pass from the closed to the lifting position, the balance beams must first of all move through an idle stroke before coming into contact with the bearing points of the bridge under the cross-tie beams S and, inversely, at the end of the lowering movement, to free these bearing points.

For this purpose, the shaft V has to make a rotary movement before, in the

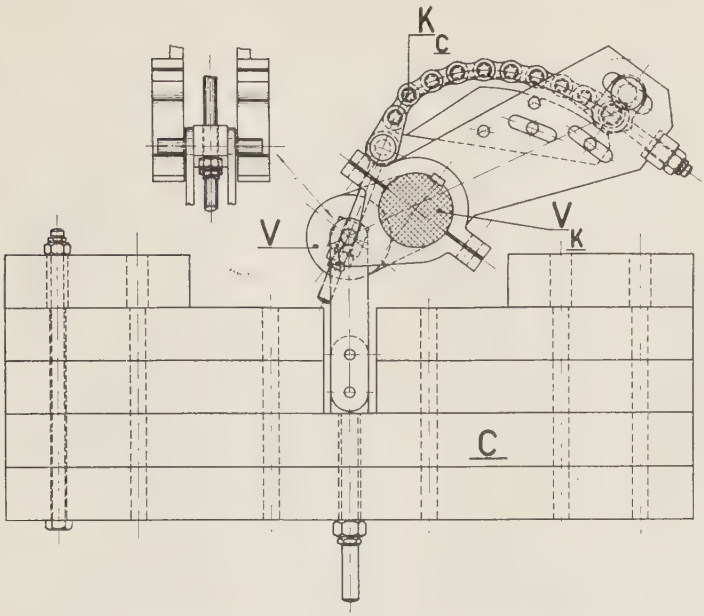


Fig. 7. — Longitudinal cross section Y-Y as shown in the transverse cross section M-M in fig. 3, with view of movable weight C. The shaft for raising the bascules off their bearings has rotated enough to allow the bascules to be opened.

case of the lifting process, the involute can come into play.

Following this rotary action, the chains K_C, to which the movable balance weights are suspended, must uncoil in circular fashion to keep the balance beams and movable loads in equilibrium.

If the angle of rotation in question is of some importance compared with that necessary for the lifting action the end of the involute may be transformed into a circle instead.

In the case of the present bridge the angle of rotation is, however, so small and the difference between the involute and the circle, relative to this angle, so slight that the correction mentioned above need not be done.

Furthermore, it should be pointed out that the balance beams are suspended from the chains K_B, coiled round the lifting shaft on a circle of small diameter. These chains are mounted, two by two, staggered by half a link with respect to each other, so as to obtain, during the rotation of the lifting shaft, as continuous a movement as possible, eliminating any jar to the balance beams.

The chains are always fixed round the lifting shaft in the form of a polygon inscribed on the latter. By mounting them as just described the length of leverage of the moment exerted by the balance beams with respect to the lifting shaft remains practically constant.

Steel wire ropes would be preferable in such a case, but their great elasticity and having to coil them round such a small diameter precludes their use.

The spans being completely supported

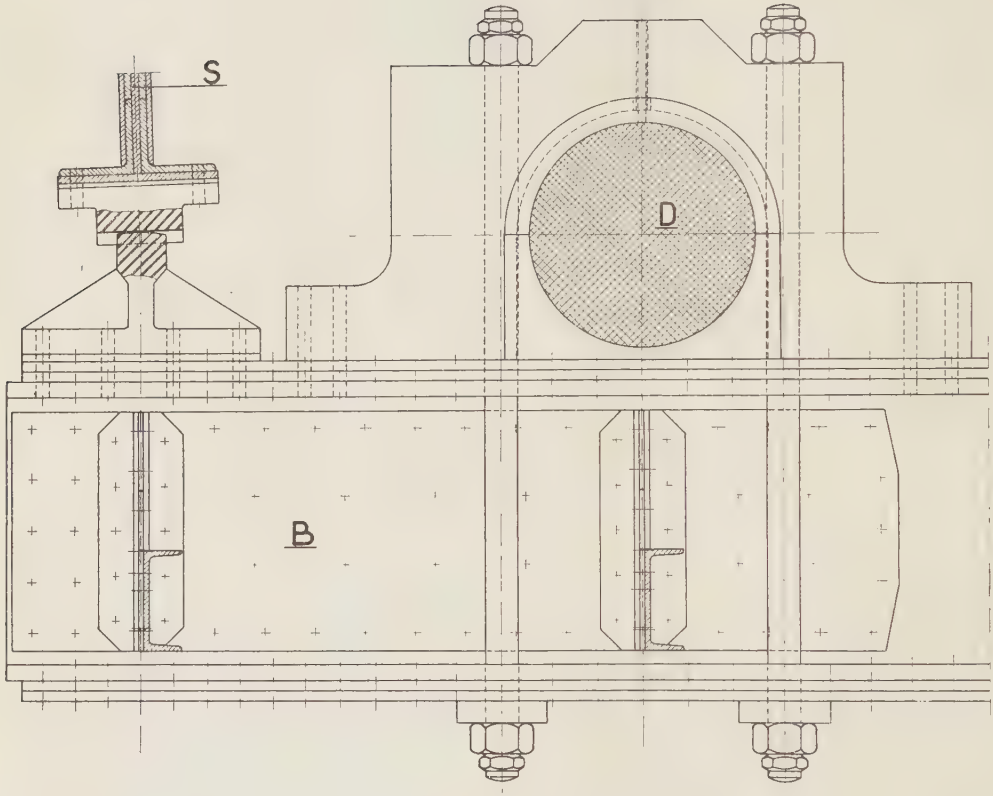
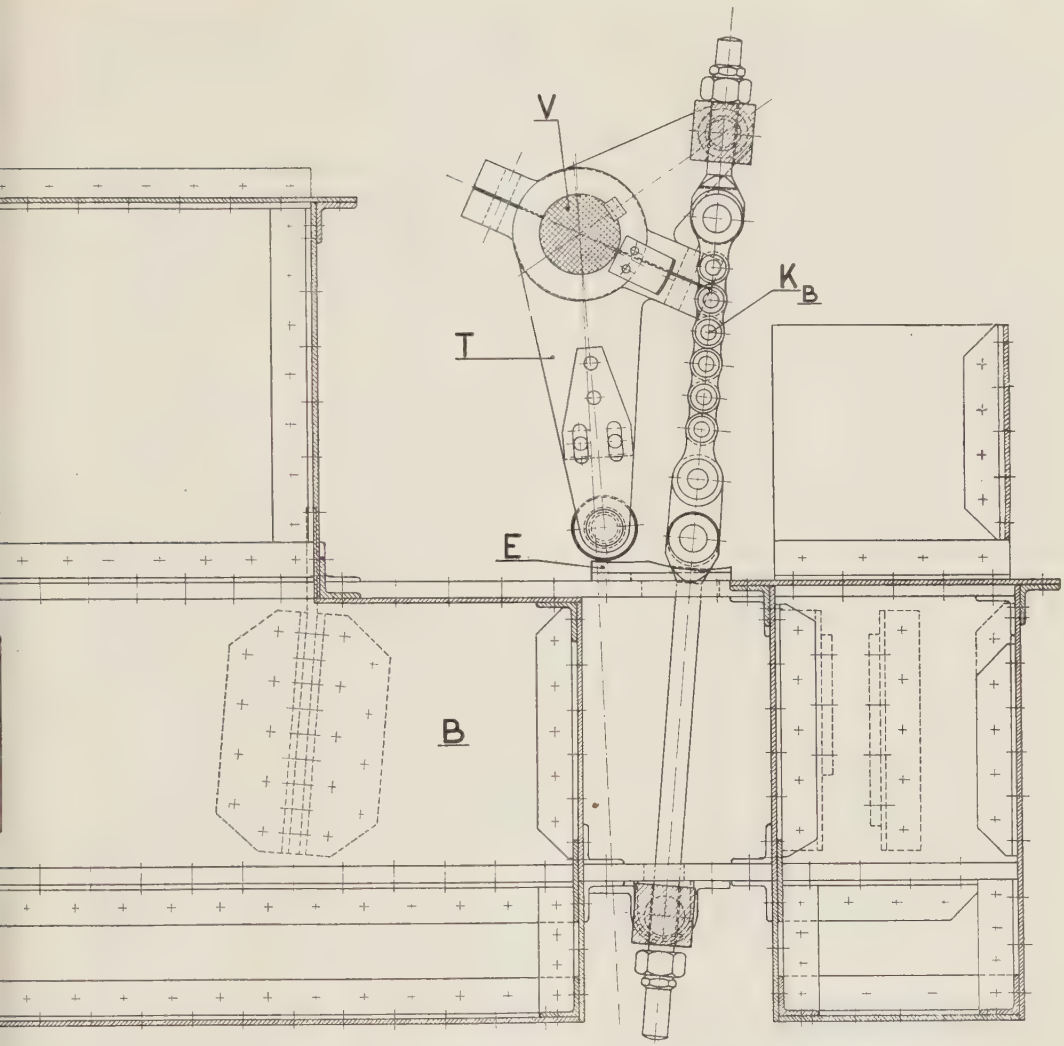


Fig. 8. — Longitudinal cross section X-X through a balance beam as shown in th
has rotated enou

by the balance beams and resting through them on the shaft round which the bridge revolves, they may now be operated.

Since the balance beams can rotate round the main bascule shaft the rotation of the latter could take place without affecting the movement of the bridge, seeing that, as already explained, the main shaft is arranged quite independently of the framework of the bridge, both vertically and horizontally.



ross section M-M in fig. 3. The shaft for raising the bascules off their bearings em to be opened.

In order to move the framework at the same time as the bascule shaft revolves (fig. 4), altogether four vertical guides F are provided for each main girder on each side of the shaft and on both its faces. These guides, owing to a certain amount of horizontal play, can slide in forged steel jaws Z, attached to the main shaft on each side of the main girder.

The changes in the elasticity of the girders can be effected without difficulty. When the bridge is closed, the bas-

cule shaft is quite free of all load. When it rotates, the bridge is taken with it, and lifted, thanks to the jaws and guides just mentioned.

At the beginning of the rotary movement the spans rest, through the balance beams, on the bascule shaft. During the movement, these beams are relieved of the weight of the bridge by the fact that it is taken up progressively by the jaws, and finally, in the open position (it is to be noted that the bridge does not move as much as 90°), this weight is almost entirely transferred by the jaws to the main bascule shaft.

When the bascules are fully raised, each of these jaws comes into contact with a bearing U fixed to the lower flange of the main girders, in such a manner that, during the rotary movement, the framework of the bascules and the balance beams form a whole with the lifting shaft.

Seeing that, during the rotary movement, the balance beams and main girders are deflected less and less (since they pass from a horizontal into an almost vertical position) the lifting shaft becomes loaded through the righting of the balance beams; under this action the end of these beams exerts a pressure against the arms T attached to the lifting shaft.

Thanks to the circular form of the curve E described by the rollers of the arms directed towards the lifting shaft, any movement around that shaft is avoided. The lifting gear, therefore, is not subjected to rotation when the bascules are being lowered. The lifting shaft V is only subjected by the load to a supplementary bending moment, which, however, is slight, thanks to the arms being mounted as closely as possible to the bearing points of the shaft.

Altogether there are four movable counterweights C, one on each side of the bascules, to ensure equilibrium between the bridge framing and the balance beams.

In addition to the fixed and movable weights and the balance beams and their counterweights, the lifting equipment in line with the short bascule arm, including motor, gearing, accessories — e. g. safety devices — also acts as a balance weight.

Except to overcome frictional resistance no external force is necessary to raise the bridges, that is to say to lift a weight of 233 t. (229.3 Engl. tons). Hence the lifting motor is only of three H.P.

That no external force is necessary for lifting the bridge, frictional resistance being neglected, results from the fact that the force is provided internally by a part of the balance weight required in line with the short bascule, which, with this object, has been made movable.

In addition, the lifting shaft V/V, formed as a crank shaft, including the arms fixed thereto and the apparatus for withdrawing the end bearings, is balanced by counterweights. These facilitate the raising and lowering of the bridge. A portion of the balance weight required to ensure the equilibrium of the bridge during the lifting process is thus given a supplementary function, the maintenance of a further equilibrium.

The bridges are operated by two sectors (see fig. 3) mounted in the control cabin. They are symmetrical with respect to the lifting shaft and fixed to it between the two bascules, being balanced with respect thereto by a counterweight.

Theoretically, these latter weights could have been made lighter than they actually are, if the weights of the sectors had been taken into account in the cal-

culations for ensuring equilibrium during rotation. However, for constructional and practical reasons this plan was not adopted.

In order to prevent the rail joints from giving rise to shocks when moving loads pass over the bascule spans a bridging device is installed to ensure continuity between the rails on the bascules and the approches thereto.

This device projects over the bascules at their rear end, and the piers at the front end.

As it projects over the rear end of the bascule, it must, together with the adjacent portion of the track, be capable of being raised, to allow the rear end of the bascule to be lifted in order to remove its bearings. This is effected by a lifting mechanism actuated from the control cabin before the bascules are raised.

The exact level of the rails at the ends of the bascules, showing them to correspond with the adjacent portions, is checked at the same time as the exact position of the movable supports O_K, situated beneath the rear end of the bascules, by means of a coupling rod, which being pushed home, bolts the balance beams in the raised position at the same time.

This bolting is necessary to prevent the balance beams from coming into action and lifting the bridge should the chains K_B by which they are suspended from the lifting shaft when the spans are closed, break.

The bridge is operated by two direct-current 25-h.p. motors which through the necessary gearing actuate the two toothed wheels engaging with the sectors.

Each motor is powerful enough to operate the two bascules by itself, so that no reserve equipment is necessary, especially as a battery of accumulators has been provided against any interruption of the main current.

In order to begin operating the bridge, the signals controlling access to it are held at stop and locked in that position by the withdrawal of the safety rocker bar referred to above. This withdrawal frees the balance beams, the rail bridge joints, and the movable bearings. Finally the rails projecting over the rear portion of the bascules are released, the bascules are lifted, and are ready to be tilted.

To close the bridge and restore freedom to the railway traffic, these operations are repeated in the reverse order.

Electric interlocking ensures that the order of movements necessary for the operation of the bridge is followed exactly. All the movements are, moreover, effected electrically from the control cabin.

The control over the adjacent road bascule bridge, as well as the operation of the gates, and road and river traffic signals, are effected from the same control board, from which point the accumulator battery and the Ward-Léonard machine set in an adjacent cabin can also be switched in.

The bascules of the railway bridge were constructed and installed by the « De Schelde » Company Ltd., of Flushing, and the electrical equipment for it and for the road bridge was supplied by the « Heemaf » Company, of Hengelo.

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Noteworthy trial run of an

Hereafter will be found particulars of a remarkable trial run carried out on July 20th, 1939, with an « electrotrain » of normal composition on the Florence-Milan line. This information was kindly supplied by Sr. Velani, General Manager of the Italian State Railways.

The 316 km. (196.4 miles) between Florence and Milan were covered in only 115 minutes, i.e. at an overall speed of 165 km. (102.5 miles) an hour.

The 97-km. (60.3 miles) hilly section between Florence and Bologne took 38 minutes, the average speed being 154 km. (95.7 miles) an hour; the 219-km. (136.1 miles) Bologne-Milan flat section, comprising many important intermediate stations, was covered in 77 minutes, i.e.

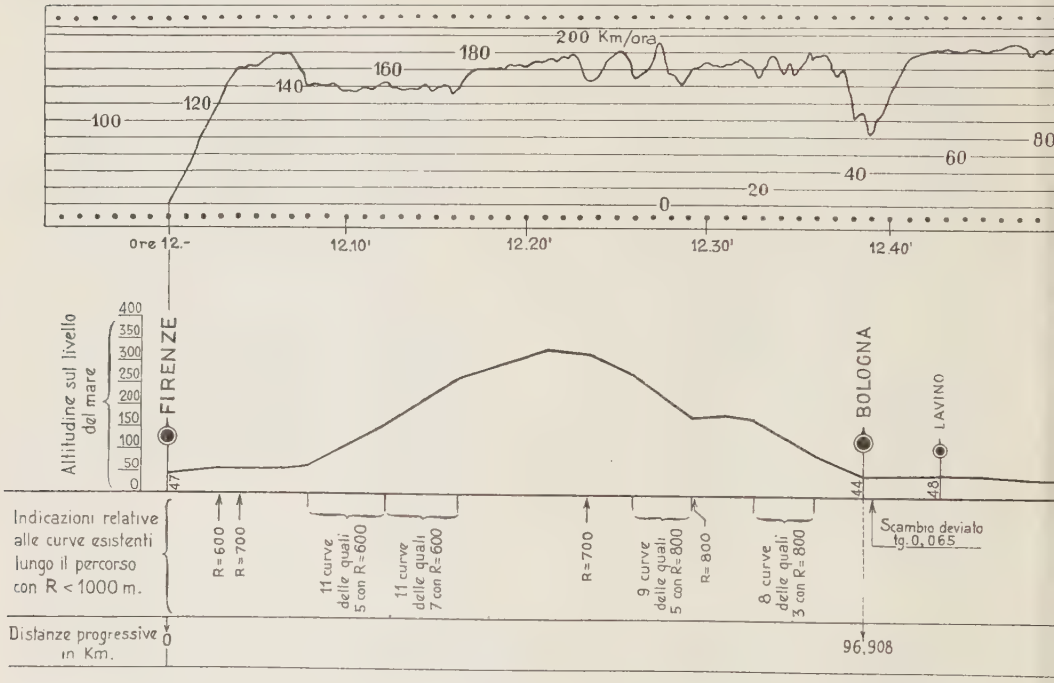


Diagram showing the speeds during the trial run w

E

Altitudine sul livello del mare = height above sea level. — Indicazioni relative alle curv
1 000-m. (50 chains) radius. — 11 (9,...) curve delle qu

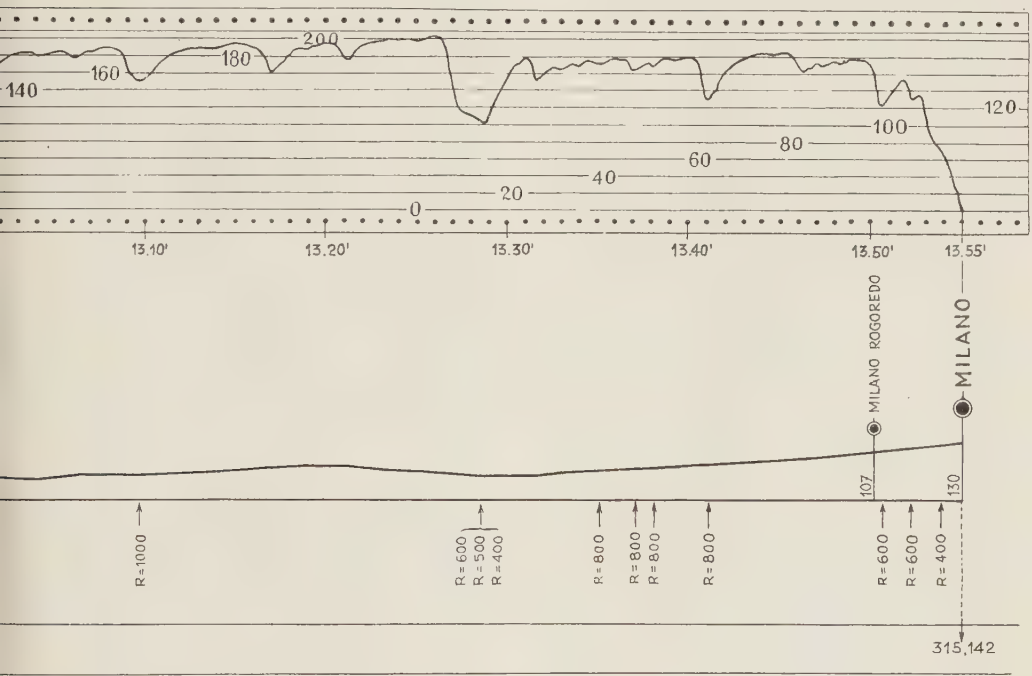
on the Florence-Milan line.

at an average speed of 171 km. (106.3 miles) an hour.

On the latter section, the 199.147 km. (123.74 miles) between the Lavino and Rogoredo stations was covered at an average speed of 175.803 km. (109.24 miles) an hour, a maximum running speed of 203 km. (126.14 miles) an hour being reached.

It appears interesting to note that the speed recorded over curves was often a little lower than the value $5.5 \sqrt{R}$ (R = curve radius in metres), and that luncheon was comfortably served to those who attended the trial run, amongst whom H. E. the Minister of Communications Benni, and about a hundred guests.

We reproduce hereafter the speed chart of this remarkable trial run.



o. 212, between Florence and Milan on July 20th, 1939.

con R < 1 000 m. = Indications relative to curves existing on the run, of less than
f which of... metres radius. — Ore = hours.

62. (01 & 669. 1]

Brittleness tests. Their importance as regards the use of carbon steels,

by J. MERKLEN, Honorary Chief Engineer, Alsace-Lorraine Railways, and E. VALLOT, Honorary Engineer, French State Railways.

(*Le Génie Civil.*)

In our previous contributions (1) we have drawn attention to the absolute necessity for users to employ only those metals which are free from brittleness, and in their specifications to insist upon the resilience test conjointly with metallographic and tensile tests, to the exclusion of most other forms of test.

In particular, in our « Note on the sudden breakage of a power distribution pylon » we have proposed that the impact tests for brittleness called for by the French Railways (2) in their specifications for structural steelwork (min. value 10 kgrm./cm² = 467 ft.-lb./sq. in., Mesnager test piece) be compulsory for all metal structures or individual members exposed to dynamic effects capable of producing accidental shocks.

The International Association for Standardisation in Ferrous Metallurgy has made no provision for resilience tests in its recommendations concerning rolled material. As a result tests for brittleness are, as far as this Association is concerned, set aside in the case of rails and structural steel work. In this connection we would recall that France (3) took the initiative in unifying the methods of testing constructional materials, and to this end, in 1891 instituted a National Commission presided over by M. Alfred Picard, who, in his inaugural address, made it clear, that *the intention of the Government was to leave the constructor completely independent,* no steps being contemplated which would restrict individual initiative in

(1) See : 1. *Revue générale des Chemins de* fer, May 1926 : « Les ruptures accidentelles des rails » (Rails broken in service), by J. MERKLEN. — 2. *Génie Civil*, 7th July, 1926 : « La fabrication des rails sains » (The manufacture of sound rails), by J. MERKLEN. — 3. *Génie Civil*, 25th May, 1929 : « Contribution à l'étude des impuretés dans les rails » (Contribution to the investigation into the impurities in rail steel), by MARQUEYROL and MERKLEN. — 4. *Génie Civil*, 5th and 12th May, 1934 : « Impuretés et avaries accidentelles des rails » (Impurities in rail steel; rails broken in service), by J. MERKLEN and E. VALLOT. — 5. *Génie Civil*, 22nd December, 1934 : « Exposé et discussion des objections faites aux conclusions de la précédente étude » (Statement and discussion of the objections raised with respect to the conclusions of the previous study), by J. MERKLEN and E. VALLOT. — 6. *Génie Civil*, 9th May, 1936 : « Ruptures et avaries accidentelles des rails » (Rails broken and damaged in service), by J. MERKLEN and E. VALLOT. — 7. *Génie Civil*, 22nd June, 1935 : « Considérations sur la rupture brusque d'un pylône de transport d'énergie » (Note on the sudden breakage of a power distribution pylon), by J. MERKLEN and E. VALLOT. — 8. *Génie Civil*, 18th June, 1938 : « Considérations générales sur la fragilité de l'acier au carbone, et conclusions à en tirer » (General comments on the brittleness of carbon steel, and conclusions to be drawn therefrom), by J. MERKLEN and E. VALLOT.

(2) See : French Railways. Main lines. Permanent way. — Specifications for metal structures. — Chapter II, Art. 4 : Mild rolled steel. Impact tests for brittleness, pages 9 and 10.

(3) See : Ch. FREMONT : 62nd Paper : *Unification des méthodes d'essais des métaux* (Standardization of metal testing methods). Paris, 1922.

the matter of testing procedure. All were to be free to employ at will and on their own responsibility any method, any desired unit, not only in respect of manufactured articles, but of raw materials also. *The object was to advise, not to legislate; to indicate methods of experiment and not to impose them; to proceed by persuasion, not by coercion* ».

Similarly, the International Association for Testing Materials, founded in 1884, stipulated in Article 10 of its statutes that « resolutions concerning technical problems represent only the opinions of the majority and are not to be regarded as other than recommendations free from any suggestion of compulsion ». This article still figures among the rules of the Association, but it has not always been respected.

The French Standards Association (AFNOR), instituted in 1918, worked in the same way. Its mission was to study and to post up standardization of specifications relating to acceptance tests for metallurgical products.

The chief aim of this standardization was to permit the works to produce cheaply and on a large scale the metals which are in wide demand. The metallurgical industry found advantage in the stabilisation and security of production, and the purchaser in the reduction in price.

The bend test on notched test pieces was to be regarded only as a source of general information. It was feared that uncertain and variable results would sometimes be obtained from one and the same steel.

On this last point the AFNOR and the International Association agreed :—

(1) To adopt the Charpy test piece with a notch 5 mm. (0.196 in.) deep (1);

(2) Not to specify resilience tests for material in as rolled or forged condition (Düsseldorf and Budapest meetings of the International Standards Association).

It would be well here to point out that, at the meetings of these Associations or Commissions, the participants (users, producers, and their advisers) all have equal voting power, whereas only the users, who are responsible for the safety of materials in service, should have this privilege, the remainder of the assembly contributing in a consulting capacity only, for example in connection with manufacturing methods and the fixing of prices. There would be no objection to the present procedure if the producer would accept moral and legal responsibility in the event of accident due to inferior quality of metal. If this cannot be so, it becomes imperative that the task of laying down the technical specifications which he deems essential to the purpose for which the material is ordered, should be the user's alone.

In France and Italy the railway specifications at present call for these tests for tyres, axles, boiler plates, engine parts, etc. In the case of materials other than for rolling stock, the specification for structural steelwork is the only one to include a test for brittleness, and this is optional.

In the case of rails, with which the Authors have been specially concerned since one of them acted as Reporter to the International Railway Congress (London Session, 1925), the test has been prescribed for record purposes in France (but only since the 1st April, 1936, while in Belgium its inception on the same basis dates from 1925).

(1) Despite this decision, Italy, Belgium, and the Permanent Way Department of the French Railways have continued to use the Mesnager test piece [notch 2 mm. (0.078 in.) deep]. In Germany the 3-mm. (0.118 in.) notch is still in use. Why wish to legislate in the face of these conflicting principles ? Would it not be simpler to adopt the 10 × 8 mm. (3/8 × 5/16 in.) Frémont test piece with a sawcut notch 1 mm. (0.039 in.) wide and 1 to 5 mm. (0.039 to 0.196 in.) deep ? This is easily prepared and it more closely resembles the sharp internal and superficial fissures wich are so disastrous in brittle steel.

It has been found that the minimum impact value of 3 kgrm./cm² (140 ft.-lb./sq. in.) (Mesnager test piece) laid down in accordance with Summary II of our paper of May 1934, was obtained in the course of manufacture at several Works in Belgium and France.

It is therefore to be hoped that all Works will progress in the same direction, and that users, on the other hand, will agree to prices which are justified by the cost of production.

Where metal structures are concerned, the requirements of the specification in respect of brittleness (min. impact value of 10 kgrm./cm² = 467 ft.-lb./sq. in.) are easily attainable.

On the question of rails, we understand that there has been some question of abandoning the impact test on small Mesnager test pieces and of substituting for it a drop test on a notched rail in full section, with a view to obtaining a minimum impact value for the full section. This procedure has been suggested by the Italian Railways (1). In this connection (2) we have shown that the result would be an average value, whereas the fixing of the minimum value remains essential on account of the heterogeneous character of even the most carefully manufactured carbon steels (3). These are not in general free from internal fissures connected with primary crystallisation or with the rolling operations [styled « hérédité de naissance » (inherent ingot defect) by Mr. Léon Guillet].

We can only repeat here that hundreds of rails which have broken in service or developed flaws have been examined in the Laboratories of the French Railways since the London Congres (1925), and that impact tests on specimens cut from the zone of impurities revealed by metallographic examination have repeatedly shown the failures to be due to brittleness of the steel.

Note. — Under our conclusion 3 of the « Considérations générales sur la fragilité de l'acier au carbone » (*Génie Civil*, 18th June, 1938), we stated that it is essential that impact tests should be made on specimens taken from suspected zones as revealed by metallography.

We intended this statement to apply to rails only for laboratory research into the causes of failure, but in the case of acceptance tests for rolled sections (in particular angles) intended for steel structures, impact test pieces must be selected in the manner described above. The mere examination of the angle bar, the section of which is shown in our above-mentioned note of June 18th, 1938, showed that $\rho = 1.509$ was found at the root of the section, while at the tips of the flanges $\rho > 22$ and 28.4 was found.

In any case, the mishaps, slight or grave, caused by brittleness of the steel — whether in railway plant or rolling stock, steel structures, steam boilers, reservoirs or high pressure gas cylinders, axles, steel wire ropes, etc., — generally involve legal responsibility on the part of the builders as stated above. These latter alone are therefore qualified to formulate those acceptance tests which in their judgment are indispensable.

In support of this, Ch. Frémont has written in the summary of his 62nd Paper :

The choice of method and the fixing of the values to be obtained in all acceptance tests should be left to the estimation of him who will later be responsible, namely the builder, who is the judge of those qualities which should be present in the metal he

(1) See *Génie Civil*, 5th May, 1934 (above mentioned article). — *Paragraph A : Fragilité, homogénéité* (brittleness, homogeneity).

(2) See *Génie Civil*, 18th June, 1938 : *Conclusions* (3).

(3) In this connection see : « Constitution physico-chimique des alliages fer-carbone », by J. SERVAIS, pp. 96 et seq. : « *L'hétérogénéité des aciers* » with its many references (H. Le Chatelier, Frémont, Charpy, Guillet, Portevin, R. Perrin, Cournot, L. Grenet, Howe, Stumper, etc.).

requires. It is he who is answerable in the case of subsequent damage or accident resulting from the use of the finished work. What is wanted is to help the builder in his choice, by placing at his disposal those tests which comply with his industrial needs.

* * *

In the concluding paragraph of our notes published in the *Génie Civil*, 18th June, 1938, we called attention to the recent accident to the road bridge at Hasselt on the Albert Canal in Belgium.

We are informed that one of the causes to which the fractures are ascribed is the *ageing* of the steel in the welds.

This term is applied to a recognised phenomenon which may be described as follows :—

If a steel having a high impact value for example 25 kgrm./cm² = 1 166 ft.-lb. /sq. in.) is deformed in the cold state and subsequently heated between 100 and 300° C., this value may be seen to fall to zero, which is precisely what may occur during the erection of welded structures.

This is therefore a question of a chance transformation within the metal, *independent of its age*, which is avoidable if non-ageing steel, such as is produced by certain makers, is used. In this way it can be ensured that after welding the steel shall retain a sufficiently high resilience value.

[656. 254]

Repeating signals in the locomotive cab by means of the " detected crocodile ", or ramp.

(Le Génie Civil.)

Experience has shown that the cab signalling apparatus known in France by the name of « crocodile » (1) is liable to certain failures. Although the railways have constantly sought to reduce the number of the latter they nevertheless persist, especially in the winter season, which is precisely the time, however, when *reliable working* is essential; for this reason it is important to see that it is obtained under all weather conditions.

Under the usual arrangement the ramp works on the open circuit principle, emitting a current to convey the signal : its circuit, normally open, is only closed at the instant when the equipment is required to function. It is therefore clear that :

— a breakdown in the circuit (wire breakage, for example,) or exhaustion of a battery, leads to a failure to act;

— the passage of current between the fixed part of the equipment (on the track) and the movable ones (on the locomotive) may, in spite of all precautions, be interfered with by atmospheric conditions : glazed frost and rime especially can stop it altogether;

— the rubbing contact between fixed and movable parts being subject to heavy wear, a very thorough inspection of the parts is indispensable, an inspection which, however strict it may be, cannot ensure that there shall never be a failure to make contact.

It appears therefore that some automatic means of checking the working is required, so that the driver may be noti-

(1) The nick-name « crocodile » has come from the fact that when the apparatus was first introduced in France, over 60 years ago, the shape of the contact ramp was supposed to bear a fancied resemblance to a crocodile. The word « ramp » is used throughout this English text *(Translator's note)*.

fied of any failure of this system of cab signalling.

With this object the « Société Parisienne-Metrum » (2) has designed and perfected a simple addition to the equipment, working on the principle of the P.A.M. inductive system of cab signalling, well known abroad and even in France, following the prolonged trial made by the Alsace-Lorraine lines (3).

Description of the « detected ramp » apparatus.

To be effective the apparatus contemplated must not comprise any mechanical contact and must be absolutely immune from atmospheric influences : this being done all wear and tear is avoided, as well as any question of encroaching on the construction gauge limits.

Inspired by these principles, the essential parts of the « Société Parisienne-Metrum » equipment comprise (fig. 2) :

(*a*) On the track :

— an inductor V which may take the form of a simple *permanent magnet* as track inductor, instead of an electro-magnet, on account of the high degree of safety in operation which it affords; even with no maintenance its magnetic power remains unchanged over many years.

(*b*) On the locomotive :

— a receiving electro-magnet ER fitted to pass over the inductor magnet V on the track;

— an impulse type receiving relay E;

— a small device, supplementing the usual recording apparatus.

The whole, forming a mere addition to the present appliances, allows of three indications being given without appreciable extra cost; it is also arranged, if desired, so as to allow of its being changed into a complete inductive cab signalling system.

Working of the « detected ramp » for giving two indications. — Fig. 1 is a diagram of the ordinary two-indication

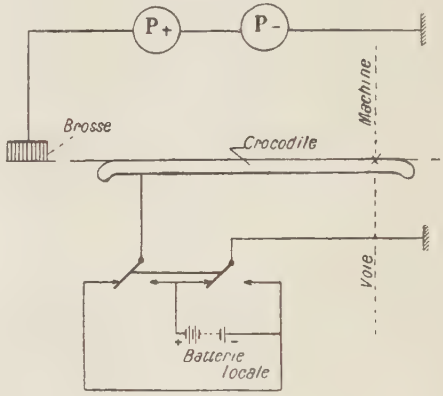


Fig. 1.

Note. — Brosse = brush. — Crocodile = ramp. — Machine = locomotive. — Voie = track. — Batterie locale = local battery.

ramp circuit. The ramp is polarised + or —, according to the position of the signal and the corresponding relay P + or P — repeats its condition in the engine cab.

Fig. 2. enables the working of the device designed by the « Société Parisienne-Metrum » to be understood.

When the locomotive passes, whatever may have been the position of the signal just encountered, the receiving electro-magnet ER passes over the permanent magnet V on the track and the magnetic field, constantly emitted by the latter, induces a voltage wave in the windings of the electro-magnet ER.

This voltage wave gives rise to a current wave, causing the receiving relay E to act, the contact E_1 of which opens and cuts off the feed to relay R. The con-

(2) « Société Parisienne pour l'Industrie des Chemins de fer et des Tramways électriques », 77, Boulevard Haussmann, Paris (8).

(3) See *Génie Civil* for January 8th, 1938; also *Bulletin of the International Railway Congress Association* for December, 1938.

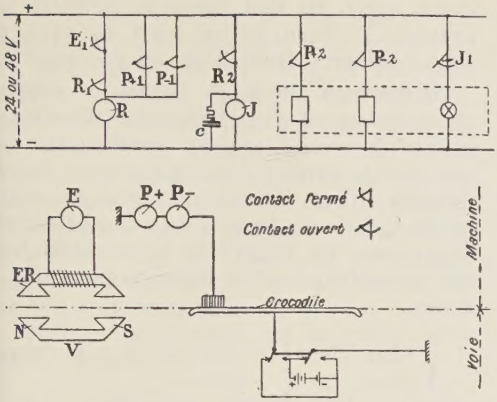


Fig. 2.

Note. — Contact fermé (ouvert) = contact closed (open).

tact R_1 keeps the circuit to relay R broken so that it remains de-energised when, after the electro-magnet has passed clear of the track permanent magnet, relay E returns to its normal condition. Contact R_2 interrupts the feed to a slow release relay J, which has a condenser *c* connected in parallel.

By means of the track inductor V, the detecting apparatus duplicates the ramp, the contacts $P+_1$ or $P-_1$ established by the latter feeding the slow release relay J through the action of relay R.

There are thus two conditions to be considered :

1. *The ramp has acted.* This action is in itself sufficient to work the recording apparatus.

2. *The ramp has not acted,* only the detecting apparatus has done so. It is then open to the railways to make use of the action of the latter, either to light up a lamp signifying « ramp out of order » or to repeat in the cab, as a matter of course, the most restrictive indication of the signal just passed.

Study of Fig. 2 will show that if the whole equipment (ramp and detecting device) has functioned correctly, the action of the ramp predominates, but that the detecting device predominates should the ramp fail to work; *consequently the detecting apparatus does not interfere in any way with the normal working of the ramp,* but supplements it each time its working is not certain, in particular in the case where the ramp has not been energised.

Safety of the system.

In Fig. 2 the receiving circuit of the detecting apparatus is not itself proved. In case of a failure (for example, wire breakage in the electro-magnet winding or in that of the receiving relay, or in the connections between electro-magnet and relay), the system would not work and the driver would not be warned. In this simple form therefore it would be incomplete.

Fig. 3 shows an arrangement for providing it with a normal proving current, itself detected by a relay K. The proving current arrives at the point M_2 where the winding of the receiving relay E separates into two equal portions; that of the receiving electro-magnet is similarly split up at M_1. This current divides in equal parts, which traverse in opposition the two halves of the winding of the electro-magnet, and the two rejoin once more at

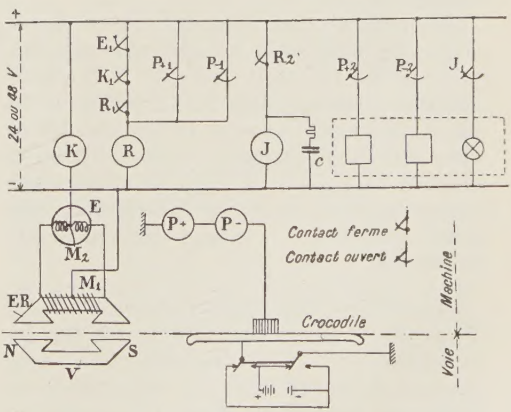


Fig. 3.

the mid-point M_1 to return to the source. The magnetising ampere-turns of the two parts of the proving current being in opposition, both in the relay and the electro-magnet, no resultant field is produced by this current, neither in the relay nor in the electro-magnet.

In normal service, when the magnet V is passed over, the induced current wave and the proving current are superimposed. In one part of the winding of ER the *sum* of the two currents is found, and in the other part, their difference.

The mid-points M_1 and M_2 being at the same potential, the induced current cannot pass into the source of the proving current; on the contrary, it passes fully into the receiving relay which acts normally as if the proving current were non-existent.

Should there be a breakdown in the receiving circuit, the proving current then only passes through half the winding of relay E which in turn brings relays R and J into action.

Anything wrong with the detecting apparatus is thus at once indicated — even apart from the passing of any signal — but leaves the working of the ramp unaffected. The indication of such a failure may or may not be combined with that referring to a ramp failure, considered above.

As regards the proving relay K, it serves in particular to indicate any failure of the proving current; it requires suitable characteristics to enable it to function under current variation due to changes of resistance. The receiving circuit, as shown in Fig. 3, is therefore fully proved in every particular, the least defect in it being automatically indicated.

Working of the system when arranged to produce three indications on the locomotive. — What the detected ramp does is to transmit to the locomotive an influence picked up from the track, an influence completely independent of the ramp itself, so that there is nothing to prevent it from being used to give a supplementary indication on the engine.

In view of the high degree of safety of working of the inductive detecting system it would appear appropriate to use it to repeat the indication most valued, either stop or caution, as may be thought best. In this way the detected ramp may be regarded as suitable for use according to the following arrangements :

I. Line clear / Stop — by the ramp + proving action.
I. Caution — by the inductive proving device.

II. Line clear / Caution — by the ramp + proving action.
II. Stop — by the inductive proving device.

Fig. 4 shows the arrangement for applying scheme II. According to whether the signal is in the line clear or caution position, the signal commutator switch connects the + or — pole of the battery to the ramp, and the opposite pole to the rail. If the signal is at stop, the ramp is not energised.

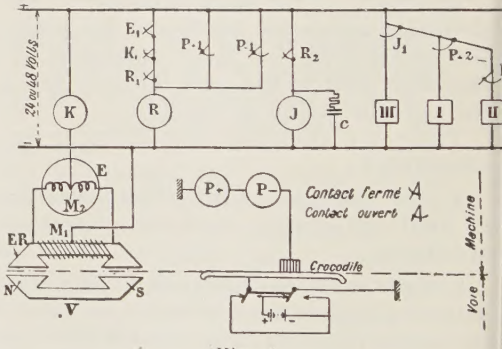


Fig. 4.

When the locomotive passes, whatever may be the position of the signal, the receiving electro-magnet ER picks up an impulse from the field of the permanent magnet; relay E acts and its contact E_1 breaks the circuit of relay R. Contact R_1 breaks the circuit of its own relay in such a way that it remains de-energised even after relay E returns to normal, electro-magnet ER having passed out of the field of permanent magnet V. Contact R_2 breaks the circuit of the slow release relay J.

Various conditions of working have to be considered :

A. — *The ramp has worked correctly.*

1. The signal is at line clear.

Relay P+ is actuated. Contact $P+_1$ closes and re-establishes the feed to relay R which, in turn, re-establishes that to relay J. Contact $P+_2$ closes the circuit to the line clear warning device I.

2. The signal is at caution :

In this case it is relay P— which is actuated. Its contact $P-_1$ cancels the influence transmitted by the proving system and its contact $P-_2$ closes circuit II of the caution warning device;

B. — *The ramp has failed to act.*

3. The signal is at stop.

4. The ramp itself is defective.

In this case the influence transmitted by the electro-magnetic system alone exists, and when the slow release relay J falls, the contact J_1 closes the circuit to the stop warning device III.

The transmission of a supplementary indication by the electro-magnetic equipment does not therefore diminish in any way the check it exercises over the working of the ramp.

Note. — The preceding explanations and diagrams have been confined to the actual principles of the system. It is clear that in giving them practical effect, they would be completed by the addition of vigilance and recording devices, and means for resetting to normal, either manual or automatic.

NEW BOOKS AND PUBLICATIONS.

[621.137 & 621.138]

SAMS (J. G. B.), Locomotive Superintendent, Kenya and Uganda Railway. — **The Locomotive Running Department.** — A volume (8 ¾ × 5 ½ inches) of 104 pages, with 55 figures. — 1939, The Locomotive Publishing Co. Ltd., 3, Amen Corner, London E. C. 4.

The *Locomotive Publishing Company* has just added to its collection of well-known handbooks dealing with the steam locomotive a short treatise on the organisation and methods used in the locomotive running department. The author deals more particularly with English practice and that of the African Colonies where climatic conditions and the employment of native labour give rise to special difficulties.

The book reviews first of all the question of types of locomotive depots, with detailed descriptions of the equipment of a large rectangular depot on the Kenya and Uganda Railway. An important chapter is devoted to the equipment and tools used in the depots : ash-pits, both the usual type and those with mechanical equipment; turntables; mechanical coaling plants; sand furnaces; boiler washing plants; wheel drops; locomotive weighing machines; methods and plant for treating the feed water.

Other chapters deal with the methods and diagrams used in the engine work-

ings, and the use of the enginemen; the organisation of the stores of the locomotive depot; the inspection and maintenance of the locomotives, and investigation into failures; the organisation of the breakdown equipment; and finally the methods of working the lines, especially single track lines.

The author dedicates his handbook to students and aspirants for railway service, but the railway engineer will also find therein a great deal of information on the various problems which crop up in the locomotive running department.

A. C.

[656 (.44)]

Code de la coordination des transports ferroviaires et routiers (*Code of rail and road transport co-ordination*). — 1939. Published by the Review *France-Transports*, 61, Boulevard Haussmann, Paris (VIII[e]). (Price : 35 French francs.)

The attempts of the French Railways to obtain a rational organisation of transport have already led to certain regulations coming into force. The first decree dealing with this matter was that of the 19th April 1934, co-ordinating railway and road transport. This was followed by others, dealing in particular with public goods transport, licences for private goods transport by road motor vehicles, taxes and licences for public transport, etc.

In 1938, owing to the results obtained and the progressive evolution of public opinion, the situation underwent a somewhat radical change. The new legislation is contained in the ten decrees of the 12th November, 1938, one of which codifies the previous regulations. A second step forward in codification was realised two months later by the decree of the 12th January, 1939. This takes the place of all the regulations not rescinded by the first codification and various other enactments.

The abstruse and complicated form of the regulations in itself contributes to the difficulty of understanding the problem. The Review *France-Transports* has done a very useful work in publishing the regulations as they appear from the latest decrees, in such a way as to facilitate reading them.

As the decree of 1939, taken as a whole and apart from certain questions, is a commentary on the application of the previous decrees, the authors adopted the logical method of printing the clauses dealing with the same matter in two columns side by side. This setting out of the text, together with a column of remarks for the guidance of the reader, is the most important part of the publication (the second part). Some parts of the pages are left blank for any possible additions to the existing regulations. This part of the work is preceded by a table of concordance of the questions dealt with, drawn up on the same principles.

The third part of the book consists of appendices and tables, giving in particular the typical formulæ for licences, standard specifications, and rating regulations. The book is completed by an alphabetical table of contents, and information of an administrative nature, together with the names and addresses of the organisations and persons belonging to them.

This original work will be of the greatest assistance to all those interested in rail and road transport.

E. M.